Case for zinc-Alzheimer's link still weak
Dr. Becky, Page 3

HEALTH AND SCIENCE

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An unlikely ally for clean water

Ozone will help destroy parasites

By Don Behm
of the Journal Sentinel staff

Ozone will become the first line of defense in protecting Milwaukee's drinking water against contamination by disease-causing organisms, beginning next spring.

The same gas that irritates eyes and restricts breathing when it accumulates in urban air will be turned against bacteria, viruses and other health menaces lurking unseen in water pumped from Lake Michigan.

This form of oxygen, containing three atoms per molecule — not two — kills or disables even the hardiest of parasites, such as Cryptosporidium, the protozoan that contaminated the city's water supply in 1993. An estimated 403,000 people were sickened and more than 100 died — making it the nation's largest waterborne disease outbreak in this century.

By April or May, ozone will be released into water being treated at the Howard Ave. purification plant on Milwaukee's south side, said city engineer Mariano Schifalacqua. The new ozone system at the Linnwood plant, on the Lake Michigan shoreline north of Bradford Beach, will be operating by June.

Ozone is both an air pollutant and an effective microbe fighter because it is unstable — one oxygen atom in the molecule is always looking for something else to latch onto. When the gas is inhaled, it can start a chemical reaction that inflames the tissue in throats and lungs.

When the gas disperses through water, a similar hunt begins, says Gordon Finch, a professor of civil engineering at the University of Alberta in Edmonton and a longtime investigator of microbes in water supplies. "Ozone wants to react with some other molecule and give up an electron," one of its oxygen atoms, Finch said.

It is more than a match for any species of Cryptosporidia.

Cryptosporidium, a microscopic single-cell parasite, lies dormant in the environment in a round shell, known as an oocyst. Four immature organisms, known as sporozoites, are tucked safely within its thick membrane. This casing can withstand extreme changes in temperature and the battering of sand and stone as it is swept downstream in rivers.

Even chlorine, the standard chemical disinfectant for the nation's water industry, does not

Please see **OZONE** *page 4*

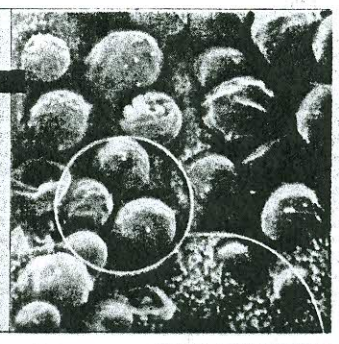
Milwaukee's large-scale water war against microscopic enemies

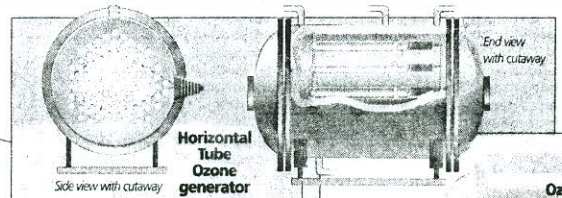
Few Milwaukee residents were aware of Cryptosporidium before 1993. Medical researchers first discovered in 1976 that this parasite caused illness in humans; federal officials had not warned communities that it could contaminate water supplies. But "crypto" became a household word in the spring of 1993 after it sickened 403,000 area residents. Today, ozone disinfection systems are being installed at the Linnwood and Howard Ave. treatment plants to prevent future disease outbreaks.

1 *Shown magnified several thousand times by an electron microscope. False color is used for contrast.*

The target: Cryptosporidium

Cryptosporidium parvum, a protozoan, is just one type of disease-causing microbe that could be drawn into the intake pipes at Milwaukee's water treatment plants. This parasite is too small to be seen with the eye. Even so, people who ingest the dormant stage of the parasite, a single cell known as an oocyst, can be sickened with cryptosporidiosis. Symptoms include diarrhea, headache, abdominal cramps, nausea, vomiting and fever. A healthy person can recover in one to two weeks.

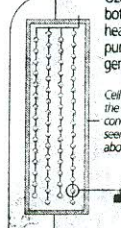




2 **The ammunition: Ozone**

Ozone will be produced from liquid oxygen at both treatment plants. First, the liquid is heated to change it into a gas. The gas is pumped into a large tank, known as a generator, that is packed with tubes carrying a 4,000-volt electrical charge. As the oxygen passes between the tubes it becomes ozone, a molecule containing three atoms of oxygen. Ozone gas is pumped into the uphill end of four contactors, covered basins separated into 12 cells each. The gas is released through an array of of 83 diffusers on the floor of the first cell.

Cell one of the ozone contactor as seen from above



How ozone will be new weapon at Linnwood treatment plant

Ozone contactors

D At the north end of the ozone building, water will pour into four covered basins, each divided into 12 cells. Water will flow down into the first cell, where ozone will be released. Gravity will force the water through the cells. As the water leaves the final cell, it is pumped to coagulation basins.

Ozone building

North filtered water reservoir

G Now disinfected, water is pumped from the reservoirs to the junction structure.

North coagulation basin

A Lake Michigan water (white arrows) is pumped into the Linnwood plant through a pipe that extends 6,565 feet off shore.

Pumping station

B The "shaft house" directs the water to the pumping station.

Shore shaft house

Junction structure

C Water will be pumped to the ozone building after construction is completed.

F New crushed anthracite and sand filters trap remaining particles and the water drops into clearwells. As water leaves clearwells, chlorine and flouride are added before the water is pumped to reservoirs.

H At the junction structure, ammonia and phosphate are added before the water is distributed to the public. Ammonia combines with chlorine to form monochloramine, a long-lasting disinfectant to prevent growth of bacteria in water mains. Phosphate reduces the acidity of treated water and limits amount of lead that can be dissolved from household pipes and faucets.

Chemical building

Filter building and clearwells

Service building

South coagulation basin

E Alum, or aluminum sulfate, is added at the coagulation basins (north is pictured above). Alum binds to particles, soils or microbes, suspended in the water and causes them to clump together. The clumps drop out of suspension and the water is pumped to the filter building.

South filtered water reservoir

OZONE CONTACTOR

Cell one

Cell five

150 ft.

24 ft.

This system will provide a concentration of up to 2.5 parts per million of ozone in each liter of water. Additional ozone can be released through diffusers in the fifth cell to maintain the desired concentration.

3 **The battlefield: Ozone contactors**

Ozone dissolves in water slowly flowing into the first cell. It settles into the same spaces between water molecules that harbor contaminants, including soil particles and tiny organisms. As water slowly flows downhill through each cell of the contactor, ozone kills cryptosporidia and other disease-causing microbes on contact. Water will remain in these basins and be exposed to ozone for a minimum of 20 minutes. Any unused ozone is removed before the water is pumped to coagulation basins, the first step in the traditional treatment process.

To coagulation basins

4 **A quick end: Crypto and other microbes are eliminated**

Ozone attacks the tough Cryptosporidium membrane *(the oocyst, figure 1)* at the atomic level. Ozone, with three oxygen atoms, is unstable. It readily gives up one atom to the carbon in the microbe's membrane, rupturing the organism. This process continues until the oocyst, and contents, are killed *(figure 2)*.

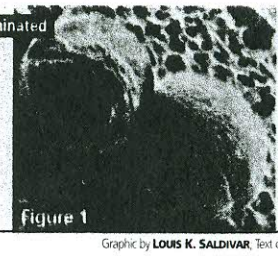


Figure 1

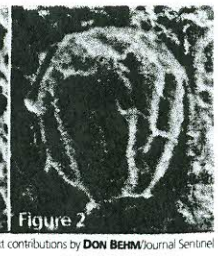


Figure 2

Sources: Milwaukee Water Works, Black & Veatch, J.F. Ahern Construction Co. Inc., Cryptosporidium photos before and after ozonation courtesy of G.R. Finch, University of Alberta

Graphic by **Louis K. Saldivar**, Text contributions by **Don Behm**/Journal Sentinel

Ozone/City to add new weapon to help safeguard drinking water

From page 1

harm Cryptosporidium at the concentrations used in treatment plants.

But ozone fights its battle in a different way. Each molecule of the gas that contacts the membrane of a Cryptosporidium oocyst attacks the shell, Finch said. It is unrelenting.

One by one, oxygen atoms jump off ozone molecules and attach themselves to carbon atoms in the membrane. This repeated reaction changes the composition of the membrane, as carbon is yanked away or pulled against the oxygen atom, making the shell more permeable, according to Finch. The next ozone molecule that comes along has an opening and the attack is renewed.

The four sporozoites, which would have been the next generation of the parasite to infect a human if the oocyst had been ingested, eventually are disabled or die.

"When it meets bacteria, which is a membrane, or pouch, that holds genetic material, the ozone steadily eats away at the membrane and the contents leak out," he said. "It also can diffuse through the wall of the membrane as openings are created and react with the genetic material inside.

"In either reaction, the ozone stops the microbe from reproducing."

Viruses, which have a more durable protein coating than bacteria, also are not resistant to it. Ozone ruptures this protective shell as any other.

But this new defense does not come cheaply. Last December, a partnership of J.S. Alberici Construction Co. of Milwaukee and Black & Veatch, a national engineering consulting firm in Kansas City, was awarded a $36.5 million contract to install ozone disinfection systems at the two Milwaukee plants.

The average annual cost of operating the new system will be about $414,000 at Linnwood and $192,000 at Howard, officials said.

The Milwaukee Water Works serves more than 820,000 people in Milwaukee and 10 suburbs. The other communities are Brown Deer, Greendale, Shorewood, Wauwatosa, West Allis, West Milwaukee, Greenfield, St. Francis, Hales Corners and a portion of Franklin.

The ozone contract marks the third major plant improvement authorized by Mayor John Norquist and the Common Council since the outbreak.

First, all old sand and gravel filters at both plants were replaced with crushed anthracite, a type of coal, and new filter drains were installed, at a cost of $14.1 million.

In addition, the city paid $9.8 million to extend by almost one mile the pipe providing Lake Michigan water to the Howard Ave. plant. The work was done to move the intake location farther from contaminants flushed down the Milwaukee River and into the harbor.

"All three pieces give Milwaukee a state-of-the-art treatment system capable of deactivating all microorganisms," said Carrie Lewis, superintendent of the Milwaukee Water Works.

The city's health department has been testing for Cryptosporidium in water coming out of both plants since the 1993 outbreak. Water samples are collected every other week and the parasite has been detected in only seven tests, Lewis said.

But the current collection and testing methods are not 100% effective. Not finding the parasite in a water sample does not guarantee none were there, officials have said. The new disinfection system will eliminate the uncertainty.

"With ozone in place, we will have much more confidence that our water is free of cryptosporidia," Lewis said.

Ozone was discovered in 1840 by German scientist Christian Schonbein. Its acrid scent spurred the scientist to name the gas for the Greek word ozein, which means "to smell." This is the smell people notice after a summer thunderstorm, when lightning rips through air to create ozone.

Today, 201 U.S. water plants depend on ozone for disinfection or as an oxidant, in which ozone gives up an atom to break apart an unwanted chemical compound such as foul-smelling and bad-tasting hydrogen sulfide. The reaction forms other compounds that are neither harmful nor smelly.

In Milwaukee, treatment plant operators will use liquid oxygen to produce ozone.

The liquid is heated and becomes a gas that is passed through a 4,000-volt electrical charge. The current breaks apart the oxygen molecule and the atoms reform as ozone, said Bob Hulsey, deputy director of water treatment technology for Black & Veatch.

It will take up to 5 kilowatt hours of electricity to produce a pound of ozone, Hulsey said. Depending on water quality and temperature, generators will produce a range of 1,240 to 6,200 pounds of ozone each day at Linnwood; 480 to 2,400 pounds each day at the smaller Howard Ave. plant.

The ozone will be pumped into newly built basins containing 12 compartments, or cells. As water flows into the first cell, ozone will be released from an array of ceramic-coated round metal heads, called diffusers.

The system is designed to mix up to 2.5 parts per million of ozone in each liter of water passing through the basins, Hulsey said. Additional ozone can be released in the fifth cell of each basin if it is needed to maintain that dose for a minimum of 20 minutes.

Even so, this maximum dose likely will be needed only in spring or after severe storms, when lake water is carrying a heavy load of soil and other organic matter — and potentially harmful microbes.

To ensure that the disinfectant is thoroughly stirred into the water, a series of concrete walls divide each basin. The water must flow up and over one wall, and then plunge down and under the next.

Any ozone escaping from the water will be collected in each basin and destroyed, Hulsey said. This will ensure that it is not released to the air and add to Milwaukee's pollution problems.

Also, water leaving the mixing basins and pumped into the plant for additional treatment will not contain any ozone. Chlorine will be added after filtering to prevent growth of bacteria in treated water as it flows through water mains and into homes and businesses.

Ozone was not always so enthusiastically embraced here.

In 1911 a team of consultants for the city discarded ozone and selected chlorine as the disinfectant of choice for a proposed water treatment plant. By the turn of the century, several European communities had begun using ozone but the technology was not effective, the consultants said.